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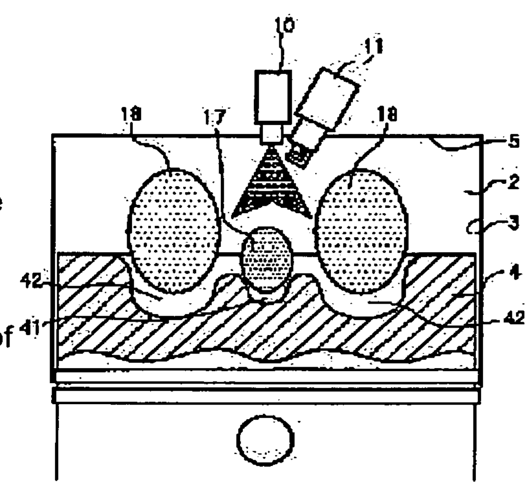
(54) INTERNAL COMBUSTION ENGINE OF DIRECT IN CYLINDER FUEL INJECTION

(57)Abstract:



PROBLEM TO BE SOLVED: To restrain the rate of increase in the pressure inside a cylinder and expanding of a compression autoignition combustion region toward the higher loaded side, by delaying the ignition time period at compression autoignition combustion time.

SOLUTION: A first cavity 41 is formed at the center of the upper surface of a piston, a second annular shape cavity 42 is formed in the periphery of the first one, and a fuel injection valve 10 is so situated in the center of a cylinder head 5, that the cylinder axis coincides with the injection direction. With two fuel injections along with one one prior to the latter half of the compression travel to near the top dead center vicinity, and with the other is before it, an enriched gas 17 is located in the first cavity 41, and a lean mixture 18 is arranged in the second cavity 42. The enriched mixture 17 is made to ignite by spark ignition, after the top dead center, and by with the heat caused by

the ignition the lean mixture 18 to is led to ignite automatically under compression.

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CLAIMS

[Claim(s)]
[Claim 1] The direct injection internal combustion engine in a cylinder characterized by constituting so that thin gaseous mixture may be allotted so that the surroundings of this enriched mixture may be surrounded, and said thin gaseous mixture may be made to result in compressed self-ignition combustion by combustion of said enriched mixture [near the top dead center] while allotting an enriched mixture in the center of abbreviation in a cylinder.
[Claim 2] The direct injection internal combustion engine in a cylinder characterized by forming the 2nd annular cavity in the perimeter of this 1st cavity while it has the fuel injection valve which injects a fuel towards abbreviation cylinder shaft orientations near the center of the cylinder head and forming the 1st cavity focusing on the abbreviation for a piston crestal plane.
[Claim 3] The direct injection internal combustion engine in a cylinder according to claim 2 characterized by constituting so that an enriched mixture may be allotted to said 1st cavity and thin gaseous mixture may be allotted to said 2nd cavity [near the top dead center].
[Claim 4] The direct injection internal combustion engine in a cylinder according to claim 3 which is the gaseous mixture to which the enriched mixture allotted to said 1st cavity results in compressed self-ignition [near the top dead center], and is characterized by making the thin gaseous mixture allotted to said 2nd cavity result in compressed self-ignition combustion by the compressed self-ignition of this enriched mixture.
[Claim 5] The direct injection internal combustion engine in a cylinder according to claim 3 characterized by making the thin gaseous mixture allotted to said 2nd cavity by lighting the enriched mixture allotted to said 1st cavity by jump spark ignition of an ignition plug result in compressed self-ignition combustion.
[Claim 6] The direct injection internal combustion engine in a cylinder of any one publication of claim 3-5 characterized by allotting an enriched mixture to said 1st cavity and allotting thin gaseous mixture to said 2nd cavity [near the top dead center] by injecting a fuel in a compression stroke by said fuel injection valve.
[Claim 7] The direct injection internal combustion engine in a cylinder of any one publication of claim 3-5 characterized by allotting an enriched mixture to said 1st cavity and allotting thin gaseous mixture to said 2nd cavity [in the same cycle] by making a fuel inject in at least 2 steps of fuel injection [/ near the top dead center], and the fuel injection before this fuel injection timing from the second half of a compression stroke.
[Claim 8] Said fuel injection valve is a fuel injection valve which can switch an angle of spray, and it sets in the same cycle. By dividing into the fuel injection which makes the fuel arranged on said 1st cavity by ******** inject, and the fuel injection which makes the fuel arranged on said 2nd cavity with an extensive angle of spray inject, and making a fuel inject The direct injection internal combustion engine in a cylinder of any one publication of claim 3-5 characterized by allotting an enriched mixture to said 1st cavity and allotting thin gaseous mixture to said 2nd cavity.
[Claim 9] The direct injection internal combustion engine in a cylinder of any one publication of claim 1-8 characterized by strengthening swirl flow to a flow by the inhalation of air in a cylinder by having two suction ports and making one [at least] suction port into a helical port.
[Claim 10] The direct injection internal combustion engine in a cylinder of any one publication of claim 1-8 characterized by strengthening swirl flow to a flow by the inhalation of air in a cylinder by

the rectification valve which was equipped with two suction ports and prepared in one [at least] suction port.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the engine which makes compressed self-ignition combustion perform especially using a fuel with the low cetane number like a gasoline about the direct injection internal combustion engine in a cylinder.
[0002]
[Description of the Prior Art] Conventionally, there were some which are indicated by JP,10-196424,A as an internal combustion engine which performs compressed self-ignition combustion. applying compression by said control piston further to the gaseous mixture which this thing was equipped with the control piston as an auxiliary compression means apart from the piston in a cylinder, and was compressed even into the elevated temperature in front of self-ignition -- it is -- the above -- it has composition to which self-ignition of the gaseous mixture is carried out all at once.
[0003] Moreover, the engine constituted so that jump spark ignition by the ignition plug might cause self-ignition is indicated by JP,11-210539,A. the gas temperature in the cylinder in the compression stroke last stage lights this thing -- gaseous mixture -- he is trying to maintain the gas temperature in the cylinder in the compression stroke last stage to the above-mentioned target temperature by judging whether it is the target temperature which causes the whole self-ignition, and controlling the valve-opening stage of an inlet valve based on this decision
[0004]
[Problem(s) to be Solved by the Invention] by the way, unlike combustion by flame propagation, compressed self-ignition combustion has the advantage that a local combustion temperature is low and NOx occurs only in ultralow volume -- on the other hand, homogeneous gaseous mixture -- at a place, in order that the whole region in a cylinder may light all at once, when gaseous mixture is made deep with a rise of a load, there is a problem that the rate of a pressure buildup in a cylinder becomes large too much, and vibration and the noise become large.
[0005] Therefore, in order to expand the load field to which compressed self-ignition combustion operation is made to perform to a heavy load side, it is necessary to set up an ignition stage near a top dead center or after it, and to control the rate of a pressure buildup in a cylinder by making the period after a top dead center produce a great portion of combustion. However, when an ignition stage is delayed near a top dead center or after it, in order that early combustion may progress with descent of a piston, combustion tends to become unstable, in order to expand the load field to which compressed self-ignition combustion operation is made to perform to a heavy load side, the stage of ignition is delayed, and the stable flammability needs to be made to be obtained.
[0006] gaseous mixture homogeneous on the other hand -- at a place, if the assistance by ignition plug which is indicated by JP,11-210539,A is applied, the ignition stage of compressed self-ignition combustion can be stabilized. However, by the above-mentioned approach, though compressed self-ignition combustion occurs near a top dead center or after it, an ignition stage cannot be delayed and effectiveness is not demonstrated for expansion by the side of the heavy load of a compressed self-ignition combustion zone.
[0007] Moreover, in compressed self-ignition combustion, an enriched-mixture place is formed locally and self-ignition or the approach of carrying out spark ignition and carrying out compressed self-ignition of the surrounding fuel by combustion from an enriched-mixture place is indicated by

JP,11-210539,A from there. However, a fuel is injected towards a piston crestal plane from the peripheral wall of the side by which the inlet valve of a combustion chamber is arranged so that it may be indicated by JP,11-210539,A. With the configuration which raises the fuel spray along with the wall surface prepared in the piston crestal plane, and is brought together in the circumference of an ignition plug In order for stopping an enriched mixture in a fixed location to supply adequately the ignition PURAGUHE enriched mixture which it was difficult and was allotted focusing on the cylinder head Since many enriched mixtures exist even if it is necessary to inject many fuels and is able to delay an ignition stage near a top dead center or after it, it is difficult to lower the rate of a pressure buildup.
[0008] this invention being made in view of the above-mentioned trouble, and carrying out compressed self-ignition of the surrounding fuel by combustion from an enriched-mixture place -- certain -- the rate of a pressure buildup -- it can control -- with -- **** -- it aims at offering the direct injection internal combustion engine in a cylinder which becomes possible [expanding a compressed self-ignition combustion zone to a heavy load side].
[0009]
[Means for Solving the Problem] Therefore, [near the top dead center], thin gaseous mixture was allotted so that the surroundings of this enriched mixture might be surrounded, and while allotting the enriched mixture in the center of abbreviation in a cylinder, it constituted from invention according to claim 1 so that said thin gaseous mixture might be made to result in compressed self-ignition combustion by combustion of said enriched mixture.
[0010] If thin gaseous mixture is annularly allotted so that this enriched mixture may be surrounded and a central enriched mixture burns by jump spark ignition or compressed self-ignition while an enriched mixture is allotted in the center of a cylinder [near the top dead center] according to this configuration, surrounding thin gaseous mixture will carry out self-ignition by that generation of heat. In invention according to claim 2, while it had the fuel injection valve which injects a fuel towards abbreviation cylinder shaft orientations near the center of the cylinder head and forming the 1st cavity focusing on the abbreviation for a piston crestal plane, it considered as the configuration which forms the 2nd annular cavity in the perimeter of this 1st cavity.
[0011] According to this configuration, by the 1st cavity formed focusing on the abbreviation for a piston crestal plane, and the 2nd annular cavity of the perimeter While the forming space of gaseous mixture is divided into a cylinder core and its perimeter, a fuel injection valve is injecting a fuel towards the abbreviation core of a piston crestal plane by setting a spraying shaft as cylinder shaft orientations, and becomes possible [allotting the gaseous mixture of concentration (air-fuel ratio) which is different in the 1st cavity and the 2nd cavity].
[0012] [near the top dead center], it constituted from invention according to claim 3 so that an enriched mixture might be allotted to said 1st cavity and thin gaseous mixture might be allotted to said 2nd cavity. According to this configuration, it is possible to make the thin gaseous mixture in the 2nd surrounding cavity result in compressed self-ignition combustion by combustion of the enriched mixture which an enriched mixture is allotted to the local field of the center of a cylinder restricted by the 1st cavity [near the top dead center], and thin gaseous mixture is annularly allotted in the 2nd cavity of the perimeter, and is allotted to the 1st cavity.
[0013] In invention according to claim 4, it is the gaseous mixture to which the enriched mixture allotted to said 1st cavity results in compressed self-ignition [near the top dead center], and considered as the configuration in which the thin gaseous mixture allotted to said 2nd cavity is made to result in compressed self-ignition combustion by the compressed self-ignition of this enriched mixture. If the enriched mixture which was allotted to the 1st cavity according to this configuration results in compressed self-ignition [near the top dead center], the thin gaseous mixture in the 2nd surrounding cavity will result in compressed self-ignition combustion by generation of heat by the combustion in this 1st cavity.
[0014] In invention according to claim 5, it considered as the configuration in which the thin gaseous mixture allotted to said 2nd cavity is made to result in compressed self-ignition combustion by lighting the enriched mixture allotted to said 1st cavity by jump spark ignition of an ignition plug. If the enriched mixture which was allotted to the 1st cavity according to this configuration is lit by jump spark ignition of an ignition plug, the thin gaseous mixture in the 2nd surrounding cavity will

result in compressed self-ignition combustion by generation of heat by the combustion in this 1st cavity.
[0015] In invention according to claim 6, it considered as the configuration which allots an enriched mixture to said 1st cavity and allots thin gaseous mixture to said 2nd cavity [near the top dead center] by injecting a fuel in a compression stroke by said fuel injection valve. According to this configuration, by injecting a fuel in a compression stroke, the fuel spray will collide with the 1st cavity, and an enriched mixture will collect at the 1st cavity, and thin gaseous mixture will be formed in the 2nd surrounding cavity of the diffusion from the 1st cavity.
[0016] In invention according to claim 7, it considered as the configuration which allots an enriched mixture to said 1st cavity and allots thin gaseous mixture to said 2nd cavity by making a fuel inject in at least 2 steps of fuel injection [/ near the top dead center], and the fuel injection before this fuel injection timing from the second half of a compression stroke [in the same cycle]. While according to this configuration the fuel injected [near the top dead center] from the second half of a compression stroke stops in the 1st cavity and an enriched mixture is formed, the fuel injected in the stage before fuel injection timing [/ near the top dead center] from this second half of a compression stroke forms thin gaseous mixture in the 2nd cavity by diffusion.
[0017] It considered as the configuration which said fuel injection valve is a fuel injection valve which can switch an angle of spray, allots an enriched mixture to said 1st cavity by dividing into the fuel injection which makes the fuel arranged on said 1st cavity by ******** in the same cycle inject, and the fuel injection which makes the fuel arranged on said 2nd cavity with an extensive angle of spray inject, and making a fuel inject, and allots thin gaseous mixture to said 2nd cavity in invention according to claim 8.
[0018] While according to this configuration supplying a fuel to the 1st cavity intensively and forming an enriched mixture by injecting a fuel by ********, thin gaseous mixture is formed in the 2nd cavity by injecting a fuel with an extensive angle of spray. In invention according to claim 9, it considered as the configuration which strengthens swirl flow to a flow by the inhalation of air in a cylinder by having two suction ports and making one [at least] suction port into a helical port.
[0019] According to this configuration, the swirl flow in a cylinder (vortex), i.e., inhalation-of-air flow which encloses the enriched mixture in the 1st cavity, is strengthened by the helical port. In invention according to claim 10, it had two suction ports and considered as the configuration which strengthens swirl flow to a flow by the inhalation of air in a cylinder by the rectification valve prepared in one [at least] suction port.
[0020] According to this configuration, inhalation-of-air flow which encloses the swirl flow in a cylinder (vortex), i.e., the enriched mixture in the 1st cavity, by the rectification valve (swirl control valve) is strengthened.
[0021]
[Effect of the Invention] By considering as the configuration which allots an enriched mixture in the center of a cylinder surrounded by thin gaseous mixture according to invention according to claim 1 By it becoming easy to allot an enriched mixture stably to a local field, and making thin gaseous mixture result in compressed self-ignition combustion by combustion of an enriched mixture It becomes possible to produce a great portion of combustion near a top dead center or after it, this controls the rate of a pressure buildup by compressed self-ignition combustion, and it is effective in the ability to expand now a compressed self-ignition combustion zone to a heavy load side.
[0022] allotting stably the gaseous mixture of concentration (air-fuel ratio) which is different in the 1st cavity and the 2nd cavity according to invention according to claim 2 -- possible -- central gaseous mixture -- the annular gaseous mixture surrounding a place and it -- it is effective in stratification-ization of gaseous mixture which consists of a place being stably realizable. When according to invention according to claim 3 stratification-ization of the gaseous mixture by which the perimeter of an enriched mixture is surrounded by thin gaseous mixture can be performed stably and it makes thin gaseous mixture result in compressed self-ignition combustion by combustion of an enriched mixture, it is effective in becoming possible to generate a great portion of combustion near a top dead center or after it by making generation of heat by combustion of an enriched mixture into necessary minimum.
[0023] Since the thin gaseous mixture allotted to the 2nd surrounding cavity by compressed self-

ignition combustion of the enriched mixture allotted to the 1st cavity is made to result in compressed self-ignition combustion according to invention according to claim 4, a great portion of combustion is generated near a top dead center or after it, the rate of a pressure buildup can be controlled, and it is effective in the ability to expand now a compressed self-ignition combustion zone to a heavy load side.
[0024] Since the thin gaseous mixture allotted to the 2nd surrounding cavity by jump-spark-ignition combustion of the enriched mixture allotted to the 1st cavity is made to result in compressed self-ignition combustion according to invention according to claim 5 While being able to generate a great portion of combustion near a top dead center or after it, being able to control the rate of a pressure buildup and being able to expand a compressed self-ignition combustion zone to a heavy load side Since jump-spark-ignition combustion of the enriched mixture allotted to the 1st cavity is carried out, it is effective in being controllable within limits which can control the rate of a pressure buildup for a self-ignition stage, and can secure combustion stability.
[0025] According to invention according to claim 6, it is effective in the ability to perform easily allotting an enriched mixture to the 1st cavity and allotting thin gaseous mixture to the 2nd cavity by injection in a compression stroke. According to invention according to claim 7, it is effective in the ability to form an enriched mixture stably in the 1st cavity by considering as the configuration which injects a fuel in 2 steps or more within the same cycle, and making the fuel injection of the 2nd henceforth perform [near the top dead center] from the second half of a compression stroke.
[0026] Since according to invention according to claim 8 an angle of spray is switched and a fuel is made to inject by to any of the 1st and 2nd cavity a fuel is supplied, while being able to allot an enriched mixture stably by the inside of the 1st cavity, the fuel penetrating power of spray becomes weaker, and it is effective in becoming possible to reduce the wall surface coating weight of a fuel because an angle of spray can extend when making the fuel supplied in the 2nd cavity inject.
[0027] It is effective in becoming possible to reduce the wall surface coating weight of the fuel at the time of making the fuel which diffusion of the enriched mixture in the 1st cavity is controlled, and can be made to perform combustion by which the enriched mixture in the 1st cavity was stabilized, and is supplied in the 2nd cavity by strengthening of the swirl flow in a cylinder inject according to invention of claim 9 and ten publications.
[0028]
[Embodiment of the Invention] The gestalt of operation of this invention is explained based on drawing below. Drawing 1 shows the gasoline engine of the direct injection in a cylinder with which this invention is applied. In this drawing 1 , an engine's 1 combustion chamber 2 is formed of a cylinder 3, a piston 4, and the cylinder head 5.
[0029] An intake valve 7 is infixed in the suction port 6 which is open for free passage to said combustion chamber 2, and the exhaust air bulb 9 is infixed in the exhaust air port 8 which is similarly open for free passage to a combustion chamber 2. Said cylinder head 5 is formed in an abbreviation flat, and the fuel injection valve 10 which injects a fuel towards cylinder shaft orientations is formed in the center of abbreviation. Moreover, an ignition plug 11 is formed in the said about ten fuel injection valve cylinder head 5 that jump spark ignition of the gaseous mixture of fuel injection valve 10 directly under should be carried out.
[0030] The 1st cavity 41 and the 2nd cavity 42 are formed in the crestal plane of said piston 4. Focusing on the crestal plane of a piston 4, said 1st cavity 41 is formed in the shape of radii so that (referring to drawing 2) and a base may become deep by circular opening in a core. Moreover, said 2nd cavity 42 is an annular cavity formed in the perimeter of said 1st cavity 41 concentric circular (refer to drawing 2), and is constituted by the base which becomes it is deep and circular from said 1st cavity 41 on the cross section of the direction of a path.
[0031] The septum 43 which separates said 1st cavity 41 and 2nd cavity 42 is formed so that it may become lower than the even piston crestal plane near the cylinder wall. The engine control unit (henceforth ECU) 20 which controls the injection quantity and fuel injection timing by said fuel injection valve 10, and the ignition timing by the ignition plug 11 By which combustion system of compressed self-ignition combustion and jump-spark-ignition combustion, operation By the combustion pattern judging section 21 which judges whether it carries out according to a service condition, the jump-spark-ignition combustion control section 22 which controls said fuel injection

valve 10 and ignition plug 11 at the time of jump-spark-ignition combustion, and the self-ignition combustion control section 23 which controls said fuel injection valve 10 and ignition plug 11 at the time of compressed self-ignition combustion It is constituted.

[0032] As shown in drawing 3 , said combustion pattern judging section 21 is a configuration which distinguishes a combustion system based on the engine load T and engine-speed N (rpm), judges a low Naka load and a low middle turn field as a compressed self-ignition combustion zone, and judges the other heavy load and quantity rotation field to be a jump-spark-ignition combustion zone. In addition, although said combustion pattern judging section 21, the jump-spark-ignition combustion control section 22, and the self-ignition combustion control section 23 can be constituted from a hard-wired logical circuit, they are realized as a program of a microcomputer with this operation gestalt.

[0033] Here, if judged with it being a jump-spark-ignition combustion zone in said combustion pattern judging section 21, as shown in drawing 4 , an inhalation-of-air line will be carrying out whole-quantity injection of the need fuel quantity at a time from said fuel injection valve 10, and, as for said jump-spark-ignition combustion control section 22, will form the gaseous mixture of homogeneity in inside at a combustion chamber. And in the ignition timing in front of a top dead center, ignition combustion of said uniform gaseous mixture is carried out by jump spark ignition of an ignition plug 11.

[0034] On the other hand, if judged with it being a compressed self-ignition combustion zone, said self-ignition combustion control section 23 will control the injection quantity and fuel injection timing by said fuel injection valve 10 [near the top dead center] in order to allot the enriched mixture 17 near SUTOIKI (theoretical air fuel ratio) to said 1st cavity 41 and to allot the gaseous mixture 18 thinner than SUTOIKI to said 2nd cavity 42 (refer to drawing 5).

[0035] As shown in drawing 4 , in the inside load field of a compressed self-ignition combustion zone, first, an inhalation-of-air line makes the 1st fuel injection perform in the first half of a compression stroke from the second half, and, specifically, the thin gaseous mixture 18 of whenever [low stratification] is formed in the field applied to the outside of the 2nd cavity 42 to the 2nd cavity 42 by this injection. The 2nd fuel injection is made to perform by the low flow rate from the 1st time [near the top dead center] after the 1st above-mentioned fuel injection from the second half of a compression stroke, and the enriched mixture 17 near SUTOIKI (theoretical air fuel ratio) is formed in said 1st cavity 41 by these 2nd fuel injection.

[0036] And the enriched mixture 17 near [which is allotted to the 1st cavity 41] SUTOIKI (theoretical air fuel ratio) is burned with spark ignition by the ignition plug 11, and the gaseous mixture 18 thinner than SUTOIKI allotted to the 2nd surrounding cavity 42 is made to result in generation of heat by this combustion behind a top dead center at compressed self-ignition combustion. Moreover, in the low loading field of a compressed self-ignition combustion zone, first, the 1st fuel injection is made to perform in the second half of a compression stroke from the first half of a compression stroke, and the thin gaseous mixture 18 of whenever [high stratification] is formed in the 2nd cavity 42 by this injection.

[0037] The 2nd fuel injection is made to perform by the low flow rate from the 1st time [near the top dead center] after the 1st above-mentioned fuel injection from the second half of a compression stroke, and the enriched mixture 17 near SUTOIKI (theoretical air fuel ratio) is formed in said 1st cavity 41 by these 2nd fuel injection. And the enriched mixture 17 near [which is allotted to the 1st cavity 41] SUTOIKI (theoretical air fuel ratio) is burned with spark ignition by the ignition plug 11, and the gaseous mixture 18 thinner than SUTOIKI allotted near [2nd cavity 42] a perimeter is made to result in generation of heat by this combustion behind a top dead center at compressed self-ignition combustion.

[0038] as mentioned above, the thing for which the enriched mixture 17 near SUTOIKI is burned by jump spark ignition behind a top dead center -- this -- if it is the configuration of making the thin gaseous mixture 18 resulting in compressed self-ignition combustion by generation of heat of gaseous mixture 17, a great portion of combustion will occur at the period after a top dead center. namely, homogeneity -- gaseous mixture -- when carrying out compressed self-ignition combustion at a place, and the conditions of a pressure and temperature are ready near a top dead center, self-ignition will be carried out all at once, an ignition stage cannot be delayed, but if it is the

configuration of making the thin gaseous mixture 18 resulting in compressed self-ignition combustion in generation of heat by combustion of an enriched mixture 17 as mentioned above, the stage of self-ignition is delayable from a top dead center.
[0039] And the rate of a pressure buildup in the cylinder leading to knocking is controlled, and a compressed self-ignition field can be made to expand to the heavy load side whose demand of fuel quantity increases because an ignition stage is overdue as shown in drawing 6 . Moreover, although the inclination in which whenever [part cylinder internal temperature / whose heat release increases] goes up as shown in drawing 6 , and an ignition stage carries out a tooth lead angle more is shown when whenever [cylinder internal temperature / which influences a compressed self-ignition stage] receives effect in the residual gas in a cylinder and a self-ignition stage carries out a tooth lead angle once As mentioned above, by burning the enriched mixture 17 near SUTOIKI by jump spark ignition If it is the configuration of making the thin gaseous mixture 18 resulting in compressed self-ignition combustion, a self-ignition stage can be controlled through a jump-spark-ignition stage, and as shown in drawing 7 , it will become possible to control a self-ignition stage within narrow limits which are in a knocking limitation and can secure combustion stability.
[0040] By moreover, the thing considered as the configuration which forms a fuel injection valve 10 so that the 1st cavity 41 may be formed in the center of a piston crestal plane, and the 2nd cavity 42 may be formed in the perimeter and a fuel may be injected towards cylinder shaft orientations in the center of a cylinder The enriched mixture 17 is allotted and stopped to the 1st cavity 41, and stratification-ization of the gaseous mixture which allots the thin gaseous mixture 18 to the 2nd surrounding cavity 42 can be performed easily. The rate of a pressure buildup can be controlled certainly that what is necessary is just to supply the minimum fuel which carries out sufficient generation of heat for making the thin gaseous mixture 18 result in compressed self-ignition combustion to the 1st cavity 41.
[0041] In addition, compressed self-ignition combustion of the enriched mixture 17 allotted to said 1st cavity 41 can be carried out, and although considered as the configuration which carries out jump spark ignition to the enriched mixture 17 near [which is allotted to said 1st cavity 41] SUTOIKI (theoretical air fuel ratio), it can also constitute from an above-mentioned operation gestalt so that the thin gaseous mixture 18 may be made to result in compressed self-ignition combustion in generation of heat by this combustion. the above-mentioned case -- homogeneity, although it becomes possible to be able to delay a great portion of combustion and to control the rate of a pressure buildup by this compared with the case where compressed self-ignition combustion of the gaseous mixture is carried out all at once If it is the configuration to which jump spark ignition of the enriched mixture 17 allotted to said 1st cavity 41 is carried out, since it is possible to control the self-ignition stage of thin gaseous mixture possible [delaying a self-ignition stage more], the self-ignition combustion stabilized more can be made to perform.
[0042] By the way, although it considered as the configuration which makes a fuel inject in 2 steps within the same cycle with the above-mentioned operation gestalt in order to allot the 1st cavity 41 at the enriched mixture 17 near SUTOIKI (theoretical air fuel ratio) and to allot the gaseous mixture 18 thinner than SUTOIKI to the 2nd cavity 42, it is possible to also make only one injection in a compression stroke generate gaseous mixture 17 and 18.
[0043] That is, if a fuel is injected in a compression stroke, while the fuel spray will collide with the 1st cavity and an enriched mixture 17 will collect on the 1st cavity 41, it is possible for the thin gaseous mixture 18 to make it form in the 2nd surrounding cavity 42 by diffusion from the 1st cavity. however, the direction considered as the configuration which makes a fuel inject in 2 steps -- the gaseous mixture of whenever [high stratification] -- it is stabilized and formation can be performed.
[0044] Moreover, in the configuration which makes a fuel inject in 2 steps, an angle of spray can be switched by the 1st injection and the 2nd injection using the fuel injection valve which can switch an angle of spray as a fuel injection valve 10. Drawing 8 is drawing showing the configuration for switching an angle of spray in a fuel injection valve 10.
[0045] Drawing 8 is the expanded sectional view of the nozzle body part of a fuel injection valve 10, and a needle valve 103 is supported movable in the vertical direction by a diagram at cylindrical centrum 102a of the nozzle body 102 in the air with which opening of the nozzle hole 101 is carried

out at a tip. Said needle valve 103 is that a tip sits down to sheet surface 101a of the shape of a earthenware mortar formed in the opening edge by the side of the interior of a nozzle hole 101, if a lift is carried out to the upper part by a diagram with the actuator which does not blockade and does not illustrate a nozzle hole 101, a nozzle hole 101 will be opened, and the fuel supplied through the fuel-supply way 104 which is open for free passage to said cylindrical centrum 102 is injected.
[0046] Moreover, a nozzle hole 101 is penetrated from the tip of said needle valve 103, and the disc-like needle-valve umbrella 105 is supported by the needle valve 103 and this alignment at the tip of the supporter material 105 of the shape of a rod prolonged even in the exterior of a nozzle body 102. In the above-mentioned configuration, when the amount of valve lifts of the needle valve 103 at the time of fuel injection is large, since said needle-valve umbrella 105 becomes far [an angle of spray becomes large, and] from a nozzle hole 101 when the amount of valve lifts is small conversely in order that said needle-valve umbrella 105 may approach by the nozzle hole 101, an angle of spray becomes small.
[0047] As mentioned above, in the fuel injection valve 10 of a configuration of being shown in drawing 8 , an angle of spray can be switched by changing the amount of valve lifts. Then, enlarge the amount of valve lifts, a fuel is made to inject with an extensive angle of spray, the amount of valve lifts is made small in the 2nd injection of a low flow rate for forming an enriched mixture in the 1st cavity 41, and a fuel is made to inject by ******** in the configuration which makes a fuel inject in the 2 above-mentioned steps in the 1st injection for forming thin gaseous mixture in the 2nd cavity 42.
[0048] If an angle of spray is narrowed in the injection for forming an enriched mixture in the 1st cavity 41 If an angle of spray is made large in the injection for forming thin gaseous mixture in the 2nd cavity 42 while it can be stabilized and a local enriched mixture can be made to form from the ability of a fuel to be intensively injected towards the 1st cavity 41 Thin gaseous mixture can be made to form in the 2nd cavity 42 of the piston crestal plane circumference, reducing wall surface coating weight, since the fuel penetrating power of spray can weaken.
[0049] However, as indicated by not the thing to limit to the configuration using a needle-valve umbrella as showed the configuration for switching an angle of spray to drawing 8 but JP,2000-145584,A, you may be the configuration of changing an angle of spray and a fuel spray travel by changing the volume of the swirl room which the opening area of the swirl hole which equips a nozzle body with a swirler and is formed in this swirler, and said swirl hole open for free passage according to the amount of lifts of a needle valve.
[0050] Moreover, since diffusion of the fuel which can equalize the gaseous mixture allotted to the 2nd cavity 42, and is arranged on the 1st cavity 41 by strengthening the swirl flow by the inhalation of air in a cylinder can be controlled, as shown in drawing 9 , the stability in self-ignition combustion can be increased. Therefore, it is desirable to add the configuration which strengthens swirl flow to a suction port 6, and there are a configuration using the helical port shown in drawing 10 and a configuration using the swirl control valve (rectification valve) shown in drawing 11 as a configuration for strengthening swirl flow.
[0051] With the configuration shown in drawing 10 , while arranging a fuel injection valve 10 and an ignition plug 11 focusing on a cylinder, it has two suction ports 6a and 6b and two exhaust air ports 8a and 8b. And it has considered as the helical port which has the effectiveness of generating a swirl for suction-port 6a of said two suction ports 6a and 6b. Moreover, although it has two suction ports 6a and 6b and two exhaust air ports 8a and 8b like the configuration shown in drawing 10 with the configuration shown in drawing 11 while arranging a fuel injection valve 10 and an ignition plug 11 focusing on a cylinder, two suction ports 6a and 6b are straight ports, and make the swirl control valve 201 have infixed in one suction-port 6a.
[0052] If the above-mentioned swirl control valve 201 is closed at the time of a low Naka load, it will become the inhalation-of-air flow which carried out eccentricity by inhalation of air being made only from suction-port 6b of another side, and swirl flow will be strengthened by this. At the time of a heavy load, said swirl control valve 201 is opened and reservation of required inspired air volume is aimed at. In addition, with each above-mentioned operation gestalt, although the configuration of the cylinder head 5 was made into the flat, as shown in drawing 12 , it is good also as a PENTO roof configuration, and the configuration of the cylinder head 5 is not limited, for example.

[Translation done.]

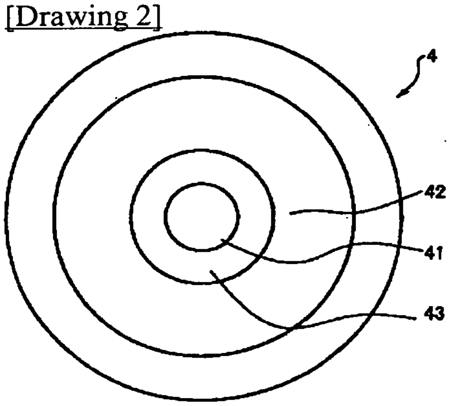
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] An internal combustion engine's block diagram in an operation gestalt.
[Drawing 2] The plan showing the cavity of a piston crestal plane in the above-mentioned internal combustion engine.
[Drawing 3] Drawing showing the self-ignition combustion zone and jump-spark-ignition combustion zone in an operation gestalt.
[Drawing 4] Drawing showing the injection timing in an operation gestalt.
[Drawing 5] The state diagram showing the formation condition of the gaseous mixture in an operation gestalt.
[Drawing 6] The diagram showing correlation with a compressed self-ignition stage, a pressure, and a generating heating value.
[Drawing 7] The diagram showing knocking and the correlation with combustion stability and an ignition stage.
[Drawing 8] The point expanded sectional view of a fuel injection valve showing the configuration for switching an angle of spray.
[Drawing 9] The diagram showing correlation with a swirl ratio and combustion stability.
[Drawing 10] Drawing showing an operation gestalt equipped with a helical port.
[Drawing 11] Drawing showing an operation gestalt equipped with a swirl control valve.
[Drawing 12] Drawing showing the operation gestalt which made the configuration of the cylinder head the PENTO roof.
[Description of Notations]
1 -- Internal combustion engine
2 -- Combustion chamber
3 -- Cylinder
4 -- Piston
5 -- Cylinder head
6 -- Suction port
7 -- Intake valve
8 -- Exhaust air port
9 -- Exhaust air bulb
10 -- Fuel injection valve
11 -- Ignition plug
20 -- Engine control unit (ECU)
21 -- Combustion pattern judging section
22 -- Jump-spark-ignition combustion control section
23 -- Self-ignition combustion control section
41 -- The 1st cavity
42 -- The 2nd cavity

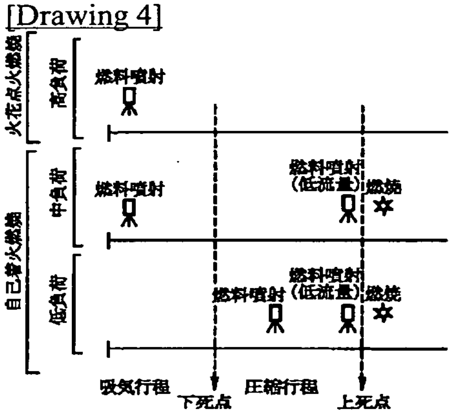
[Translation done.]

DRAWINGS

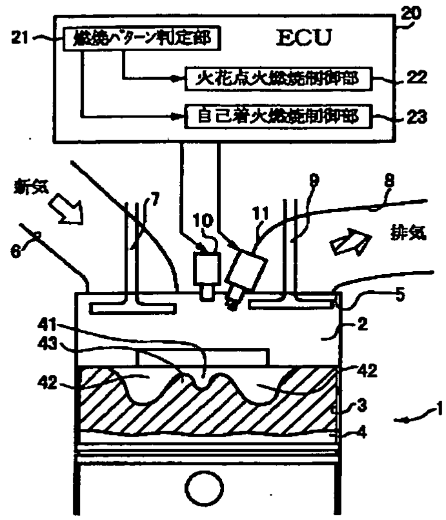
[Drawing 2]



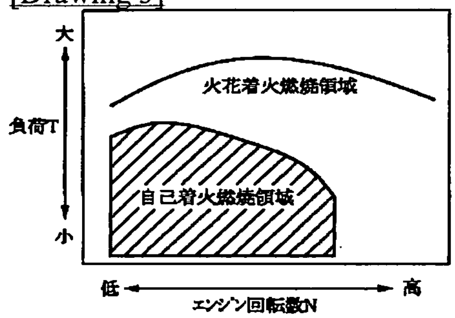
[Drawing 4]



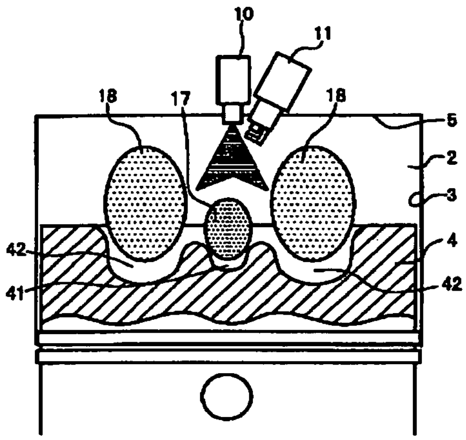
[Drawing 1]



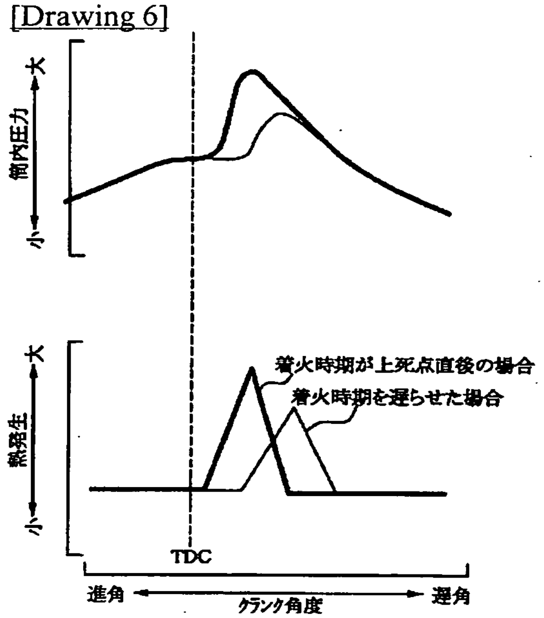
[Drawing 3]



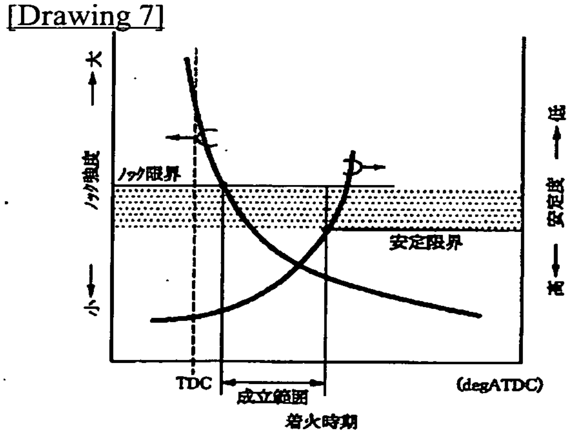
[Drawing 5]



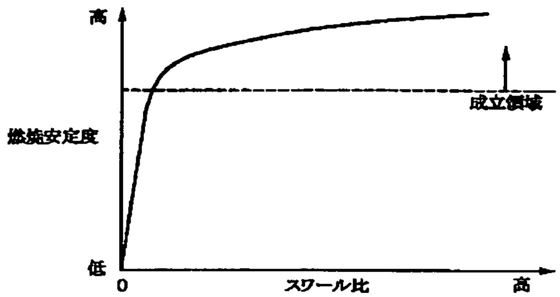
[Drawing 6]



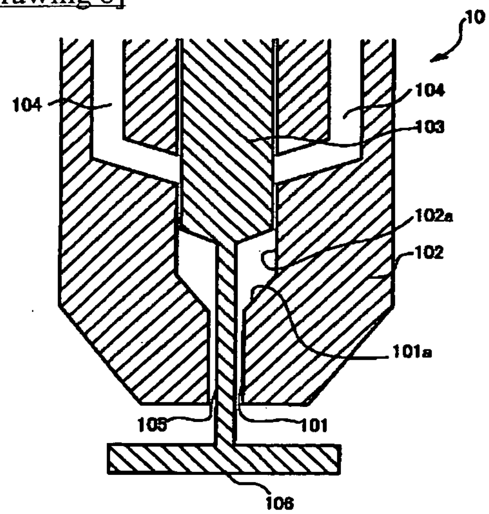
[Drawing 7]



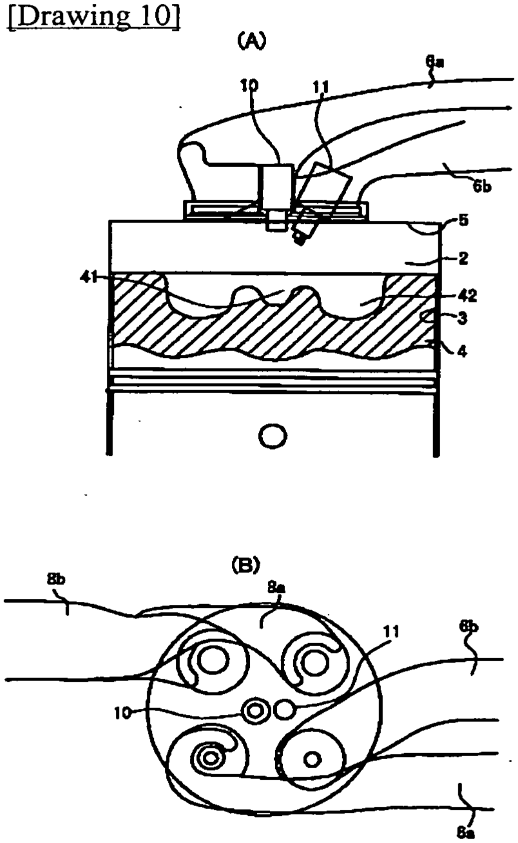
[Drawing 9]



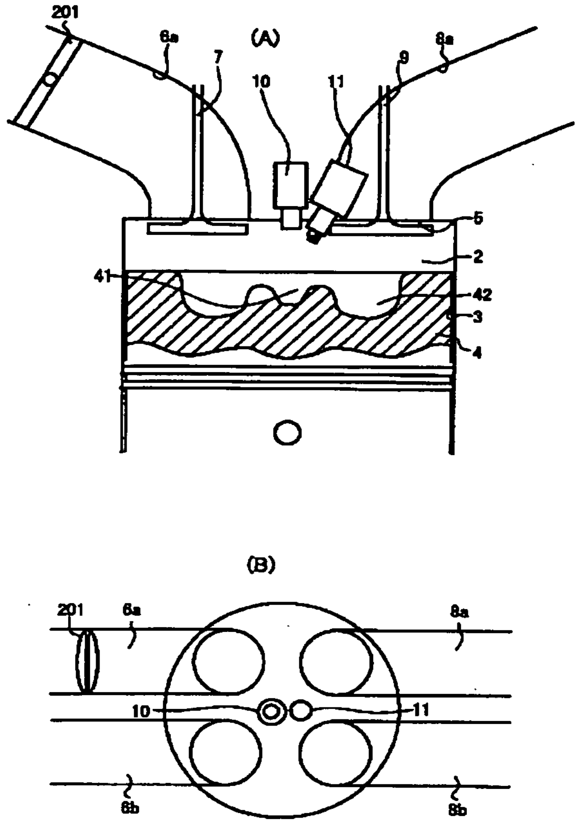
[Drawing 8]



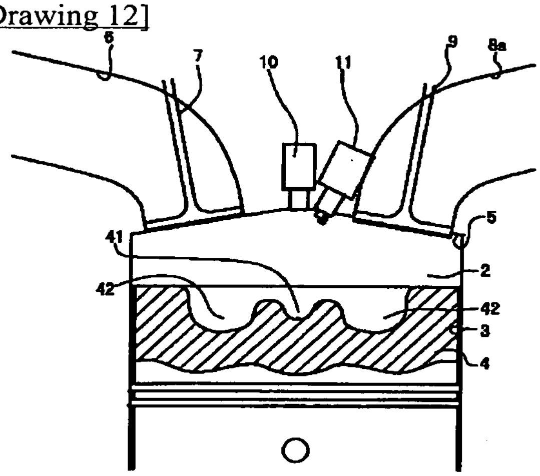
[Drawing 10]



[Drawing 11]



[Drawing 12]



[Translation done.]

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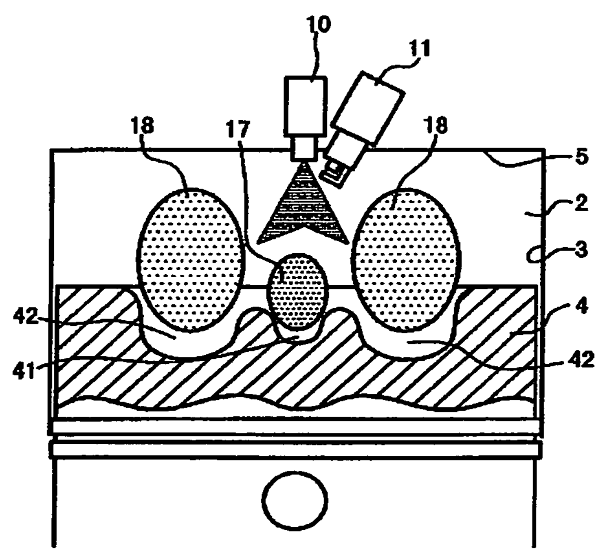
最終頁に続く

(54)【発明の名称】筒内直接噴射式内燃機関

(57)【要約】

【課題】圧縮自己着火燃焼時に着火時期を遅らせることで、筒内圧の上昇率を抑制し、圧縮自己着火燃焼領域の高負荷側への拡大を可能にする。

【解決手段】ピストン冠面の中央に第１キャビティ４１を形成し、その周囲に環状の第２キャビティ４２を形成する一方、燃料噴射弁１０を、シリンダヘッド５の中央にシリンダ軸方向が噴射方向となるように設ける。そして、圧縮行程後半から上死点近傍における噴射とそれ以前の噴射との２回の燃料噴射によって、上死点近傍において第１キャビティ４１に濃い混合気１７を配し、第２キャビティ４２に薄い混合気１８を配し、濃い混合気１７を上死点後に火花点火によって燃焼させ、該燃焼による発熱で薄い混合気１８を圧縮自己着火燃焼に至らしめる。



【特許請求の範囲】
【請求項１】上死点近傍において、シリンダ内の略中央に濃い混合気を配すると共に、該濃い混合気の周りを囲むように薄い混合気を配し、前記濃い混合気の燃焼により前記薄い混合気を圧縮自己着火燃焼に至らしめるよう構成したことを特徴とする筒内直接噴射式内燃機関。
【請求項２】シリンダヘッドの中央付近に略シリンダ軸方向に向け燃料を噴射する燃料噴射弁を備える一方、ピストン冠面の略中心に第１キャビティを形成すると共に、該第１キャビティの周囲に環状の第２キャビティを形成したことを特徴とする筒内直接噴射式内燃機関。
【請求項３】上死点近傍において、前記第１キャビティに濃い混合気を配し、前記第２キャビティに薄い混合気を配するよう構成したことを特徴とする請求項２記載の筒内直接噴射式内燃機関。
【請求項４】前記第１キャビティに配した濃い混合気が上死点近傍において圧縮自己着火に至る混合気であり、該濃い混合気の圧縮自己着火により、前記第２キャビティに配した薄い混合気を圧縮自己着火燃焼に至らしめることを特徴とする請求項３記載の筒内直接噴射式内燃機関。
【請求項５】前記第１キャビティに配した濃い混合気を点火プラグの火花点火によって着火させることにより、前記第２キャビティに配した薄い混合気を圧縮自己着火燃焼に至らしめることを特徴とする請求項３記載の筒内直接噴射式内燃機関。
【請求項６】前記燃料噴射弁により圧縮行程中に燃料を噴射することにより、上死点近傍において、前記第１キャビティに濃い混合気を配し、前記第２キャビティに薄い混合気を配することを特徴とする請求項３～５のいずれか１つに記載の筒内直接噴射式内燃機関。
【請求項７】同一サイクル内において、圧縮行程後半から上死点近傍における燃料噴射と、該噴射時期よりも前の燃料噴射との少なくとも２回に分けて燃料を噴射させることで、前記第１キャビティに濃い混合気を配し、前記第２キャビティに薄い混合気を配することを特徴とする請求項３～５のいずれか１つに記載の筒内直接噴射式内燃機関。
【請求項８】前記燃料噴射弁が噴霧角の切り換えが可能な燃料噴射弁であって、同一サイクル内において、狭噴霧角により前記第１キャビティに配する燃料を噴射させる燃料噴射と、広噴霧角により前記第２キャビティに配する燃料を噴射させる燃料噴射とに分けて燃料を噴射させることで、前記第１キャビティに濃い混合気を配し、前記第２キャビティに薄い混合気を配することを特徴とする請求項３～５のいずれか１つに記載の筒内直接噴射式内燃機関。
【請求項９】２つの吸気ポートを備え、少なくとも一方の吸気ポートをヘリカルポートとすることにより、シリンダ内の吸気による流動に対しスワール流れを強化することを特徴とする請求項１～８のいずれか１つに記載の筒内直接噴射式内燃機関。
【請求項１０】２つの吸気ポートを備え、少なくとも一方の吸気ポートに設けた整流弁により、シリンダ内の吸気による流動に対しスワール流れを強化することを特徴とする請求項１～８のいずれか１つに記載の筒内直接噴射式内燃機関。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、筒内直接噴射式内燃機関に関し、特に、ガソリンのようなセタン価の低い燃料を用いて圧縮自己着火燃焼を行わせる機関に関する。
【０００２】
【従来の技術】従来、圧縮自己着火燃焼を行う内燃機関として、特開平１０－１９６４２４号公報に開示されるものがあった。このものは、シリンダ内のピストンとは別に、補助圧縮手段としてコントロールピストンを備え、自己着火寸前の高温にまで圧縮された混合気に対し、前記コントロールピストンによる圧縮をさらに加えることで、上記混合気を一斉に自己着火させる構成となっている。
【０００３】また、点火プラグによる火花点火により自己着火を引き起こすよう構成された機関が、特開平１１－２１０５３９号公報に開示されている。このものは、圧縮行程末期におけるシリンダ内のガス温度が、点火すると混合気全体の自己着火を引き起こす目標温度であるか否かを判断し、この判断に基づいて吸気弁の開弁時期を制御することにより、圧縮行程末期におけるシリンダ内のガス温度を上記目標温度に維持するようにしている。
【０００４】
【発明が解決しようとする課題】ところで、圧縮自己着火燃焼は、火炎伝播による燃焼と異なり、局所的な燃焼温度が低く、ＮＯｘが極微量にしか発生しないという利点があるが、その反面、均質な混合気場においては、シリンダ内全域が一斉に着火するため、負荷の上昇に伴って混合気を濃くすると、シリンダ内の圧力上昇率が大きくなりすぎ、振動・騒音が大きくなるという問題がある。
【０００５】従って、圧縮自己着火燃焼運転を行わせる負荷領域を高負荷側に拡大するためには、着火時期を上死点付近又はそれ以降に設定し、大部分の燃焼を上死点より後の期間に生じさせることで、シリンダ内の圧力上昇率を抑制する必要がある。しかしながら、着火時期を上死点付近又はそれ以降に遅らせた場合には、ピストンの下降と共に初期の燃焼が進むことになるため、燃焼が不安定になり易く、圧縮自己着火燃焼運転を行わせる負荷領域を高負荷側に拡大するためには、着火の時期を遅らせ、かつ、安定した燃焼性が得られるようにする必要

がある。

【０００６】一方、均質な混合気場において、特開平１１－２１０５３９号公報に開示されるような点火プラグによるアシストを適用すれば、圧縮自己着火燃焼の着火時期を安定させることができる。しかし、上記の方法では、上死点付近又はそれ以降に圧縮自己着火燃焼が発生するとしても、着火時期を遅らせることができず、圧縮自己着火燃焼領域の高負荷側への拡大には効果を発揮しない。

【０００７】また、圧縮自己着火燃焼において、局所的に濃い混合気場を形成し、そこから自己着火或いは火花着火させ、濃い混合気場からの燃焼により周囲の燃料を圧縮自己着火させる方法が特開平１１－２１０５３９号公報に開示されている。しかし、特開平１１－２１０５３９号公報に開示されるように、燃焼室の吸気弁が配置される側の周壁からピストン冠面に向け燃料を噴射し、ピストン冠面に設けられた壁面に沿って燃料噴霧を持ち上げて点火プラグ周りに集める構成では、濃い混合気を一定の場所に留めておくことが困難であって、シリンダヘッド中心に配した点火プラグへ濃い混合気を安定供給するためには、多くの燃料を噴射する必要があり、上死点付近もしくはそれ以降に着火時期を遅らせることができたとしても、濃い混合気が多く存在するため、圧力上昇率を下げることは困難である。

【０００８】本発明は上記問題点に鑑みなされたものであり、濃い混合気場からの燃焼により周囲の燃料を圧縮自己着火させることで、確実に圧力上昇率を抑制することができ、以って、圧縮自己着火燃焼領域を高負荷側に拡大することが可能となる筒内直接噴射式内燃機関を提供することを目的とする。

【０００９】

【課題を解決するための手段】そのため、請求項１記載の発明では、上死点近傍において、シリンダ内の略中央に濃い混合気を配すると共に、該濃い混合気の周りを囲むように薄い混合気を配し、前記濃い混合気の燃焼により前記薄い混合気を圧縮自己着火燃焼に至らしめるよう構成した。

【００１０】かかる構成によると、上死点近傍において、シリンダ中央に濃い混合気が配される一方、この濃い混合気を取り囲むよう環状に薄い混合気が配され、中央の濃い混合気が火花点火或いは圧縮自己着火によって燃焼すると、その発熱によって周囲の薄い混合気が自己着火する。請求項２記載の発明では、シリンダヘッドの中央付近に略シリンダ軸方向に向け燃料を噴射する燃料噴射弁を備える一方、ピストン冠面の略中心に第１キャビティを形成すると共に、該第１キャビティの周囲に環状の第２キャビティを形成する構成とした。

【００１１】かかる構成によると、ピストン冠面の略中心に形成される第１キャビティとその周囲の環状の第２キャビティとによって、混合気の形成場がシリンダ中心部とその周囲とに分けられる一方、燃料噴射弁は、シリンダ軸方向を噴霧軸としてピストン冠面の略中心に向けて燃料を噴射することで、第１キャビティと第２キャビティとに異なる濃度（空燃比）の混合気を配することが可能となる。

【００１２】請求項３記載の発明では、上死点近傍において、前記第１キャビティに濃い混合気を配し、前記第２キャビティに薄い混合気を配するよう構成した。かかる構成によると、上死点近傍において第１キャビティにより制限されるシリンダ中央の局所的な領域に濃い混合気が配され、その周囲の第２キャビティ内には環状に薄い混合気が配され、第１キャビティに配される濃い混合気の燃焼により、周囲の第２キャビティ内の薄い混合気を圧縮自己着火燃焼に至らしめることが可能である。

【００１３】請求項４記載の発明では、前記第１キャビティに配した濃い混合気が上死点近傍において圧縮自己着火に至る混合気であり、該濃い混合気の圧縮自己着火により、前記第２キャビティに配した薄い混合気を圧縮自己着火燃焼に至らしめる構成とした。かかる構成によると、第１キャビティに配した濃い混合気が上死点近傍において圧縮自己着火に至ると、該第１キャビティにおける燃焼による発熱によって、周囲の第２キャビティ内の薄い混合気が圧縮自己着火燃焼に至る。

【００１４】請求項５記載の発明では、前記第１キャビティに配した濃い混合気を点火プラグの火花点火によって着火させることにより、前記第２キャビティに配した薄い混合気を圧縮自己着火燃焼に至らしめる構成とした。かかる構成によると、第１キャビティに配した濃い混合気を点火プラグの火花点火によって着火させると、該第１キャビティにおける燃焼による発熱によって、周囲の第２キャビティ内の薄い混合気が圧縮自己着火燃焼に至る。

【００１５】請求項６記載の発明では、前記燃料噴射弁により圧縮行程中に燃料を噴射することにより、上死点近傍において、前記第１キャビティに濃い混合気を配し、前記第２キャビティに薄い混合気を配する構成とした。かかる構成によると、圧縮行程中に燃料を噴射することで、燃料噴霧が第１キャビティに衝突して、第１キャビティに濃い混合気が溜まり、また、第１キャビティからの拡散によって周囲の第２キャビティに薄い混合気が形成されることになる。

【００１６】請求項７記載の発明では、同一サイクル内において、圧縮行程後半から上死点近傍における燃料噴射と、該噴射時期よりも前の燃料噴射との少なくとも２回に分けて燃料を噴射させることで、前記第１キャビティに濃い混合気を配し、前記第２キャビティに薄い混合気を配する構成とした。かかる構成によると、圧縮行程後半から上死点近傍において噴射される燃料は、第１キャビティ内に留まって濃い混合気を形成する一方、該圧縮行程後半から上死点近傍における噴射時期よりも前の

時期において噴射された燃料は、拡散によって第２キャビティに薄い混合気を形成する。

【００１７】請求項８記載の発明では、前記燃料噴射弁が噴霧角の切り換えが可能な燃料噴射弁であって、同一サイクル内において、狭噴霧角により前記第１キャビティに配する燃料を噴射させる燃料噴射と、広噴霧角により前記第２キャビティに配する燃料を噴射させる燃料噴射とに分けて燃料を噴射させることで、前記第１キャビティに濃い混合気を配し、前記第２キャビティに薄い混合気を配する構成とした。

【００１８】かかる構成によると、狭噴霧角で燃料を噴射することで、第１キャビティに集中的に燃料を供給して濃い混合気を形成する一方、広噴霧角で燃料を噴射することで、第２キャビティに薄い混合気が形成される。請求項９記載の発明では、２つの吸気ポートを備え、少なくとも一方の吸気ポートをヘリカルポートとすることにより、シリンダ内の吸気による流動に対しスワール流れを強化する構成とした。

【００１９】かかる構成によると、ヘリカルポートによってシリンダ内におけるスワール流れ（渦流）、即ち、第１キャビティ内の濃い混合気を取り囲むような吸気流れが強化される。請求項１０記載の発明では、２つの吸気ポートを備え、少なくとも一方の吸気ポートに設けた整流弁により、シリンダ内の吸気による流動に対しスワール流れを強化する構成とした。

【００２０】かかる構成によると、整流弁（スワールコントロールバルブ）によってシリンダ内におけるスワール流れ（渦流）、即ち、第１キャビティ内の濃い混合気を取り囲むような吸気流れが強化される。

【００２１】

【発明の効果】請求項１記載の発明によると、薄い混合気で囲まれるシリンダ中央に濃い混合気を配する構成とすることで、濃い混合気を局所的な領域に安定的に配することが容易となり、また、濃い混合気の燃焼により薄い混合気を圧縮自己着火燃焼に至らしめることで、大部分の燃焼を上死点付近又はそれ以降に生じさせることが可能となり、これにより圧縮自己着火燃焼による圧力上昇率を抑制して、圧縮自己着火燃焼領域を高負荷側に拡大することができるようになるという効果がある。

【００２２】請求項２記載の発明によると、第１キャビティと第２キャビティとに異なる濃度（空燃比）の混合気を安定的に配することが可能で、中央の混合気場とそれを囲む環状の混合気場とからなる混合気の成層化を安定的に実現できるという効果がある。請求項３記載の発明によると、濃い混合気の周囲が薄い混合気で囲まれる混合気の成層化を安定的に行え、濃い混合気の燃焼によって薄い混合気を圧縮自己着火燃焼に至らしめる場合に、濃い混合気の燃焼による発熱を必要最小限として、大部分の燃焼を上死点付近もしくはそれ以降に発生させることが可能になるという効果がある。

【００２３】請求項４記載の発明によると、第１キャビティに配される濃い混合気の圧縮自己着火燃焼により周囲の第２キャビティに配される薄い混合気を圧縮自己着火燃焼に至らしめるので、大部分の燃焼を上死点付近もしくはそれ以降に発生させ、圧力上昇率を抑制することができ、圧縮自己着火燃焼領域を高負荷側に拡大することができるようになるという効果がある。

【００２４】請求項５記載の発明によると、第１キャビティに配される濃い混合気の火花点火燃焼により周囲の第２キャビティに配される薄い混合気を圧縮自己着火燃焼に至らしめるので、大部分の燃焼を上死点付近もしくはそれ以降に発生させ、圧力上昇率を抑制することができ、圧縮自己着火燃焼領域を高負荷側に拡大することができると共に、第１キャビティに配される濃い混合気を火花点火燃焼させるので、自己着火時期を、圧力上昇率を抑制できかつ燃焼安定度を確保できる範囲内に制御することができるという効果がある。

【００２５】請求項６記載の発明によると、圧縮行程中の噴射によって、第１キャビティに濃い混合気を配し、第２キャビティに薄い混合気を配することが容易に行えるという効果がある。請求項７記載の発明によると、同一サイクル内で２回以上に分けて燃料を噴射する構成とし、かつ、圧縮行程後半から上死点近傍において２回目以降の燃料噴射を行わせることで、第１キャビティ内に安定的に濃い混合気を形成することができるという効果がある。

【００２６】請求項８記載の発明によると、第１，第２キャビティのいずれに燃料を供給するかによって噴霧角を切り換えて燃料を噴射させるので、第１キャビティ内により安定的に濃い混合気を配することができると共に、第２キャビティ内に供給する燃料を噴射させるときに噴霧角が広げられることで、燃料噴霧の貫通力が弱まり、燃料の壁面付着量を低減することが可能となるという効果がある。

【００２７】請求項９，１０記載の発明によると、シリンダ内におけるスワール流れの強化によって、第１キャビティ内の濃い混合気の拡散が抑制され、第１キャビティ内の濃い混合気の安定した燃焼を行わせることができ、また、第２キャビティ内に供給する燃料を噴射させるときの燃料の壁面付着量を低減することが可能となるという効果がある。

【００２８】

【発明の実施の形態】以下に本発明の実施の形態を図に基づいて説明する。図１は、本発明が適用される筒内直接噴射式のガソリン機関を示す。この図１において、機関１の燃焼室２は、シリンダ３，ピストン４，シリンダヘッド５によって形成される。

【００２９】前記燃焼室２に連通する吸気ポート６には吸気バルブ７が介装され、同じく燃焼室２に連通する排気ポート８には排気バルブ９が介装される。前記シリン

ダヘッド５は略フラットに形成され、その略中央には、シリンダ軸方向に向けて燃料を噴射する燃料噴射弁１０が設けられる。また、前記燃料噴射弁１０近傍のシリンダヘッド５には、燃料噴射弁１０直下の混合気を火花点火すべく点火プラグ１１が設けられる。

【００３０】前記ピストン４の冠面には、第１キャビティ４１及び第２キャビティ４２が形成される。前記第１キャビティ４１は、ピストン４の冠面中心に、円形の開口部で（図２参照）、かつ、底面が中心ほど深くなるように円弧状に形成される。また、前記第２キャビティ４２は、前記第１キャビティ４１の周囲に同心円状に形成される環状のキャビティであり（図２参照）、前記第１キャビティ４１よりも深くかつ径方向の横断面で円弧状となる底面によって構成される。

【００３１】前記第１キャビティ４１と第２キャビティ４２とを隔てる隔壁４３は、シリンダ壁近傍の平らなピストン冠面よりも低くなるように形成される。前記燃料噴射弁１０による噴射量・噴射時期及び点火プラグ１１による点火時期を制御するエンジンコントロールユニット（以下、ＥＣＵという）２０は、圧縮自己着火燃焼と火花点火燃焼とのいずれの燃焼方式で運転を行うかを運転条件に応じて判定する燃焼パターン判定部２１、火花点火燃焼時に前記燃料噴射弁１０及び点火プラグ１１を制御する火花点火燃焼制御部２２、圧縮自己着火燃焼時に前記燃料噴射弁１０及び点火プラグ１１を制御する自己着火燃焼制御部２３によって構成される。

【００３２】前記燃焼パターン判定部２１は、図３に示すように、機関負荷ＴとエンジンＮ（rpm）に基づいて燃焼方式を判別する構成であり、低中負荷・低中回転領域を圧縮自己着火燃焼領域として判定し、それ以外の高負荷・高回転領域を火花点火燃焼領域と判定する。尚、前記燃焼パターン判定部２１，火花点火燃焼制御部２２及び自己着火燃焼制御部２３は、ハードワイヤードの論理回路で構成することが可能であるが、本実施形態では、マイクロコンピュータのプログラムとして実現される。

【００３３】ここで、前記燃焼パターン判定部２１で火花点火燃焼領域であると判定されると、前記火花点火燃焼制御部２２は、図４に示すように、吸気行程中に前記燃料噴射弁１０から必要燃料量を１度に全量噴射することで、燃焼室内に均一の混合気を形成する。そして、上死点前の点火時期において、点火プラグ１１の火花点火により前記均一な混合気を着火燃焼させる。

【００３４】一方、圧縮自己着火燃焼領域であると判定されると、前記自己着火燃焼制御部２３は、上死点近傍において、前記第１キャビティ４１にストイキ（理論空燃比）付近の濃い混合気１７を配し、前記第２キャビティ４２にストイキよりも薄い混合気１８を配すべく（図５参照）、前記燃料噴射弁１０による噴射量及び噴射時期を制御する。

【００３５】具体的には、図４に示すように、圧縮自己着火燃焼領域の中負荷領域では、まず、吸気行程後半から圧縮行程前半において１度目の燃料噴射を行わせ、この噴射により第２キャビティ４２から第２キャビティ４２の外側にかけた領域に、低成層度の薄い混合気１８を形成する。上記１度目の燃料噴射の後、圧縮行程後半から上死点近傍において、１度目よりも低流量で２度目の燃料噴射を行わせ、この２度目の燃料噴射によって前記第１キャビティ４１にストイキ（理論空燃比）付近の濃い混合気１７を形成する。

【００３６】そして、上死点後に、第１キャビティ４１に配されるストイキ（理論空燃比）付近の濃い混合気１７を点火プラグ１１による火花着火により燃焼させ、該燃焼による発熱で、周囲の第２キャビティ４２に配されるストイキよりも薄い混合気１８を圧縮自己着火燃焼に至らしめる。また、圧縮自己着火燃焼領域の低負荷領域では、まず、圧縮行程前半から圧縮行程後半において１度目の燃料噴射を行わせ、この噴射により第２キャビティ４２に、高成層度の薄い混合気１８を形成する。

【００３７】上記１度目の燃料噴射の後、圧縮行程後半から上死点近傍において、１度目よりも低流量で２度目の燃料噴射を行わせ、この２度目の燃料噴射によって前記第１キャビティ４１にストイキ（理論空燃比）付近の濃い混合気１７を形成する。そして、上死点後に、第１キャビティ４１に配されるストイキ（理論空燃比）付近の濃い混合気１７を点火プラグ１１による火花着火により燃焼させ、該燃焼による発熱で、周囲の第２キャビティ４２付近に配されるストイキよりも薄い混合気１８を圧縮自己着火燃焼に至らしめる。

【００３８】上記のように、ストイキ近傍の濃い混合気１７を上死点後に火花点火によって燃焼させることにより、該混合気１７の発熱によって薄い混合気１８を圧縮自己着火燃焼に至らしめる構成であれば、大部分の燃焼が上死点よりも後の期間に発生することになる。即ち、均一混合気場で圧縮自己着火燃焼させる場合には、上死点付近で圧力及び温度の条件が整ったときに一斉に自己着火することになり、着火時期を遅らせることができないが、上記のように、濃い混合気１７の燃焼による発熱で、薄い混合気１８を圧縮自己着火燃焼に至らしめる構成であれば、上死点から自己着火の時期を遅らせることができる。

【００３９】そして、図６に示すように、着火時期が遅れることで、ノッキングの原因となるシリンダ内の圧力上昇率が抑制され、圧縮自己着火領域を燃料量の要求が増える高負荷側に拡大させることができる。また、圧縮自己着火時期を左右するシリンダ内温度は、シリンダ内の残留ガスに影響を受け、１度自己着火時期が進角すると、図６に示すように熱発生が多くなる分シリンダ内温度が上昇し、着火時期がより進角する傾向を示すが、上記のように、ストイキ近傍の濃い混合気１７を火花点火

によって燃焼させることにより、薄い混合気１８を圧縮自己着火燃焼に至らしめる構成であれば、自己着火時期を、火花点火時期を介して制御でき、図７に示すように、ノッキング限界内でかつ燃焼安定度を確保できる狭い範囲内に、自己着火時期を制御することが可能となる。

【００４０】また、ピストン冠面の中央に第１キャビティ４１、その周囲に第２キャビティ４２を設け、かつ、シリンダ中央にシリンダ軸方向に向けて燃料を噴射するように燃料噴射弁１０を設ける構成としたことで、濃い混合気１７を第１キャビティ４１に配して留めておき、薄い混合気１８を周囲の第２キャビティ４２に配する混合気の成層化が容易に行え、薄い混合気１８を圧縮自己着火燃焼に至らしめるのに充分な発熱をする最低限の燃料を第１キャビティ４１に供給すれば良く、圧力上昇率を確実に抑制することができる。

【００４１】尚、上記実施形態では、前記第１キャビティ４１に配されるストイキ（理論空燃比）付近の濃い混合気１７に火花点火する構成としたが、前記第１キャビティ４１に配される濃い混合気１７を圧縮自己着火燃焼させ、該燃焼による発熱で薄い混合気１８を圧縮自己着火燃焼に至らしめるよう構成することもできる。上記の場合も、均一混合気を一斉に圧縮自己着火燃焼させる場合に比べて、大部分の燃焼を遅らせることができ、これによって、圧力上昇率を抑制することが可能となるが、前記第１キャビティ４１に配される濃い混合気１７を火花点火させる構成であれば、より自己着火時期を遅らせることが可能で、かつ、薄い混合気の自己着火時期を制御することが可能であるので、より安定した自己着火燃焼を行わせることができる。

【００４２】ところで、上記実施形態では、第１キャビティ４１にストイキ（理論空燃比）付近の濃い混合気１７に配し、第２キャビティ４２にストイキよりも薄い混合気１８を配するために、同一サイクル内で２回に分けて燃料を噴射させる構成としたが、圧縮行程中の１回の噴射のみによって、混合気１７，１８の生成を行わせることも可能である。

【００４３】即ち、圧縮行程中に燃料を噴射すれば、燃料噴霧が第１キャビティに衝突し、第１キャビティ４１に濃い混合気１７が溜まる一方、第１キャビティからの拡散によって周囲の第２キャビティ４２に薄い混合気１８が形成させることが可能である。但し、２回に分けて燃料を噴射させる構成とした方が、高成層度の混合気形成が安定して行える。

【００４４】また、燃料噴射弁１０として噴霧角を切り換えることが可能な燃料噴射弁を用い、２回に分けて燃料を噴射させる構成において、１回目の噴射と２回目の噴射とで噴霧角を切り換えるようにすることができる。図８は、燃料噴射弁１０において噴霧角を切り換えるための構成を示す図である。

【００４５】図８は、燃料噴射弁１０のノズルボディ部分の拡大断面図であり、先端に噴孔１０１が開口される中空のノズルボディ１０２の円筒状中空部１０２ａに、針弁１０３が図で上下方向に移動可能に支持される。前記針弁１０３は、噴孔１０１の内部側の開口端に形成されるすり鉢状のシート面１０１ａに先端が着座することで、噴孔１０１を閉塞するものであり、図示しないアクチュエータによって図で上方にリフトすると噴孔１０１が開かれ、前記円筒状中空部１０２に連通する燃料供給路１０４を介して供給される燃料が噴射される。

【００４６】また、前記針弁１０３の先端から噴孔１０１を貫通して、ノズルボディ１０２の外部にまで延びる棒状の支持部材１０５の先端には、針弁１０３と同心に円盤状の針弁傘１０５が支持されている。上記構成において、燃料噴射時の針弁１０３のバルブリフト量が大きい場合には、前記針弁傘１０５が噴孔１０１により近づくために噴霧角が大きくなり、逆に、バルブリフト量が小さい場合には、前記針弁傘１０５が噴孔１０１から遠くなるため噴霧角は小さくなる。

【００４７】上記のように、図８に示す構成の燃料噴射弁１０においては、バルブリフト量を変化させることで噴霧角を切り換えることができる。そこで、上記の２回に分けて燃料を噴射させる構成において、第２キャビティ４２に薄い混合気を形成するための１回目の噴射において、バルブリフト量を大きくして広噴霧角で燃料を噴射させ、第１キャビティ４１に濃い混合気を形成するための２回目の低流量の噴射においては、バルブリフト量を小さくして狭噴霧角で燃料を噴射させる。

【００４８】第１キャビティ４１に濃い混合気を形成するための噴射において噴霧角を狭くすれば、第１キャビティ４１に向け集中的に燃料を噴射できることから、局所的な濃い混合気を安定して形成させることができる一方、第２キャビティ４２に薄い混合気を形成するための噴射において噴霧角を広くすると、燃料噴霧の貫通力が弱められることから、壁面付着量を低減させつつ、ピストン冠面周辺の第２キャビティ４２に薄い混合気を形成させることができる。

【００４９】但し、噴霧角を切り換えるための構成を、図８に示したような針弁傘を用いる構成に限定するものではなく、例えば特開２０００－１４５５８４号公報に開示されるように、ノズルボディにスワーラを備え、該スワーラに形成されるスワール孔の開口面積及び前記スワール孔が連通するスワール室の容積を、針弁のリフト量に応じて変化させることで、噴霧角及び噴霧到達距離を変化させる構成であっても良い。

【００５０】また、シリンダ内における吸気によるスワール流れを強化することで、第２キャビティ４２に配する混合気を均一化でき、また、第１キャビティ４１に配する燃料の拡散を抑制することができることから、図９に示すように、自己着火燃焼における安定度を増大させ

ることができる。従って、吸気ポート６にスワール流れを強化する構成を付加することが好ましく、スワール流れを強化するための構成としては、図１０に示すヘリカルポートを用いる構成や、図１１に示すスワールコントロールバルブ（整流弁）を用いる構成がある。

【００５１】図１０に示す構成では、シリンダ中心に燃料噴射弁１０及び点火プラグ１１を配する一方、２つの吸気ポート６ａ，６ｂ及び２つの排気ポート８ａ，８ｂを備える。そして、前記２つの吸気ポート６ａ，６ｂのうちの吸気ポート６ａを、スワールを発生させる効果を有するヘリカルポートとしてある。また、図１１に示す構成では、図１０に示した構成と同様に、シリンダ中心に燃料噴射弁１０及び点火プラグ１１を配する一方、２つの吸気ポート６ａ，６ｂ及び２つの排気ポート８ａ，８ｂを備えるが、２つの吸気ポート６ａ，６ｂはストレートポートであり、一方の吸気ポート６ａにスワールコントロールバルブ２０１を介装させてある。

【００５２】上記スワールコントロールバルブ２０１を低中負荷時に閉じると、他方の吸気ポート６ｂのみから吸気がなされることで偏心した吸気流れとなり、これによってスワール流れが強化される。高負荷時には、前記スワールコントロールバルブ２０１を開いて必要な吸気量の確保を図る。尚、上記各実施形態では、シリンダヘッド５の形状をフラットとしたが、例えば、図１２に示すようにペントルーフ形状としても良く、シリンダヘッド５の形状を限定するものではない。

【図面の簡単な説明】

【図１】実施形態における内燃機関の構成図。

【図２】上記内燃機関においてピストン冠面のキャビティを示す上面図。

【図３】実施形態における自己着火燃焼領域と火花点火燃焼領域とを示す図。

【図４】実施形態における噴射タイミングを示す図。

【図５】実施形態における混合気の形成状態を示す状態図。

【図６】圧縮自己着火時期と圧力及び発生熱量との相関を示す線図。

【図７】ノッキング及び燃焼安定度と着火時期との相関を示す線図。

【図８】噴霧角を切り換えるための構成を示す燃料噴射弁の先端部拡大断面図。

【図９】スワール比と燃焼安定度との相関を示す線図。

【図１０】ヘリカルポートを備える実施形態を示す図。

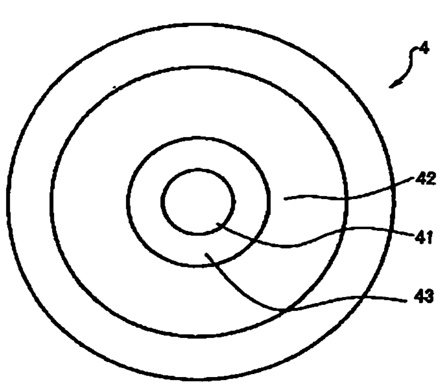
【図１１】スワールコントロールバルブを備える実施形態を示す図。

【図１２】シリンダヘッドの形状をペントルーフとした実施形態を示す図。

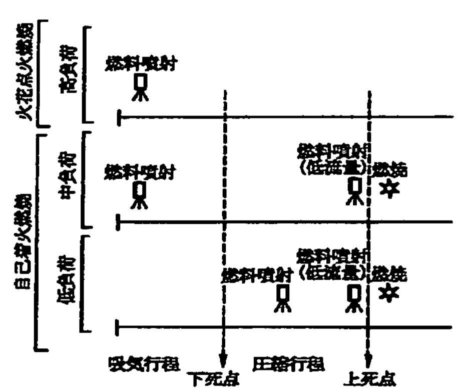
【符号の説明】

１…内燃機関
２…燃焼室
３…シリンダ
４…ピストン
５…シリンダヘッド
６…吸気ポート
７…吸気バルブ
８…排気ポート
９…排気バルブ
１０…燃料噴射弁
１１…点火プラグ
２０…エンジンコントロールユニット（ＥＣＵ）
２１…燃焼パターン判定部
２２…火花点火燃焼制御部
２３…自己着火燃焼制御部
４１…第１キャビティ
４２…第２キャビティ

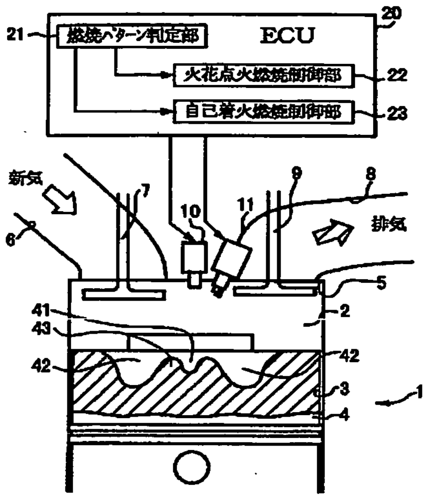
【図２】



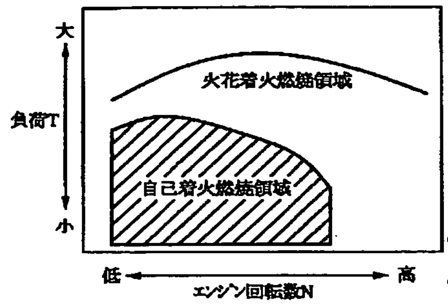
【図４】



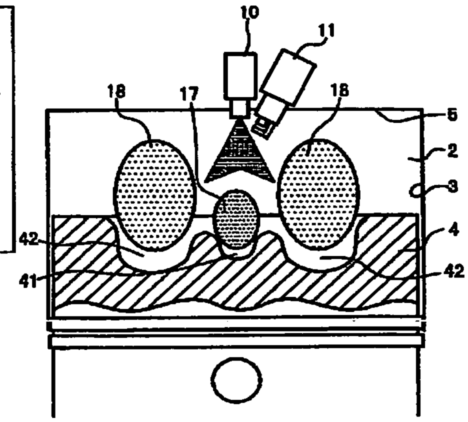
【図１】



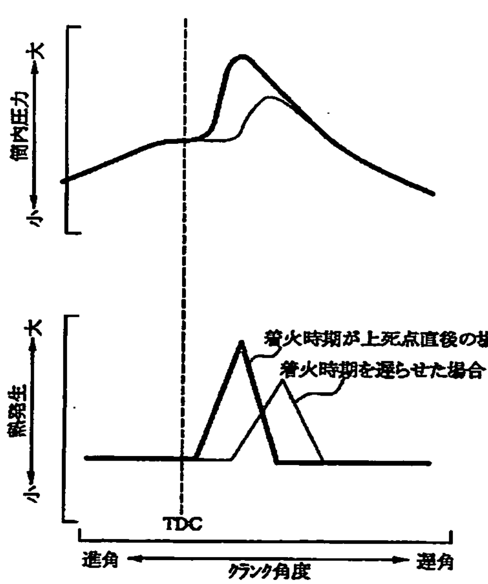
【図３】



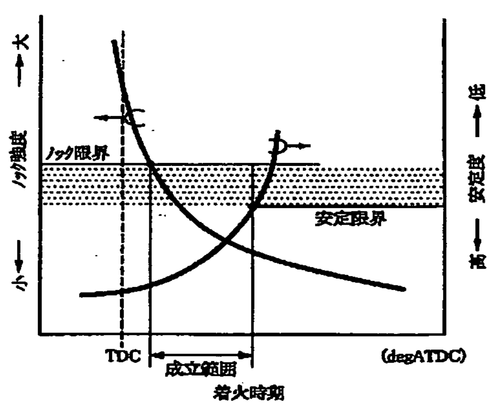
【図５】



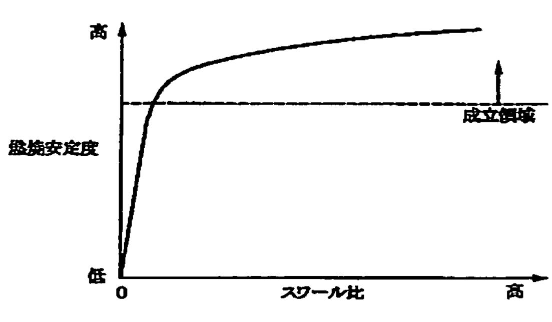
【図６】



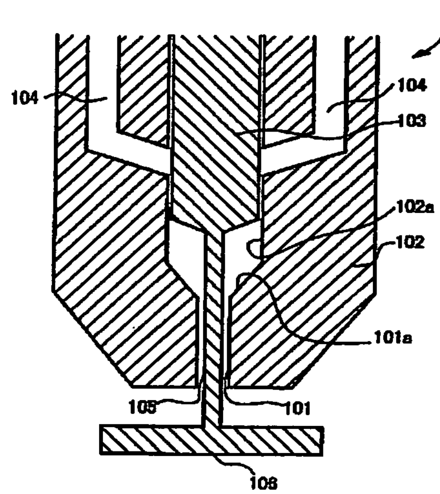
【図７】



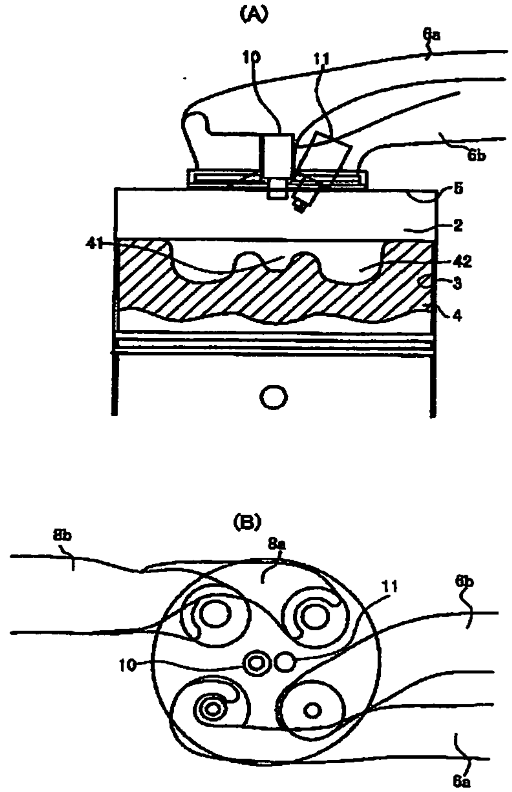
【図９】



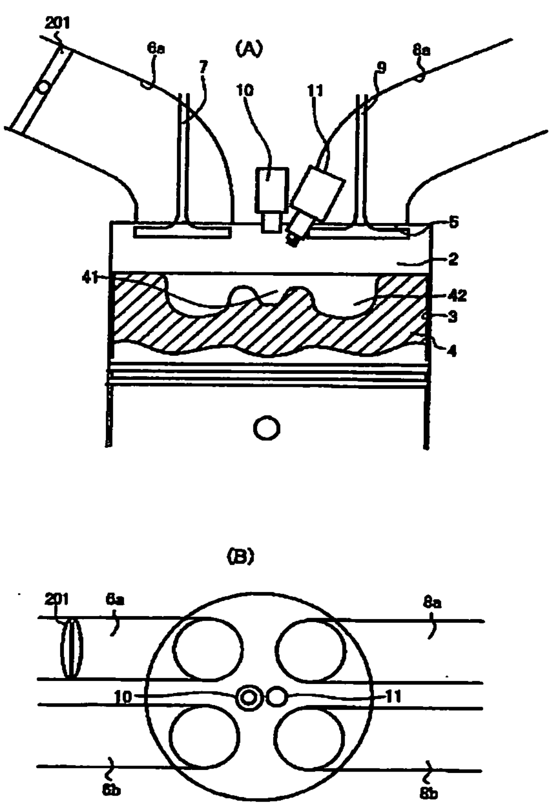
【図８】



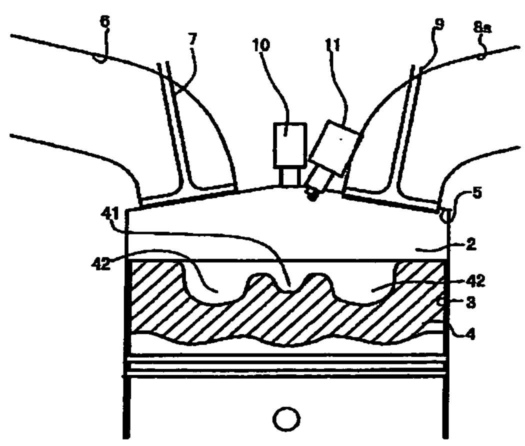
【図１０】



【図１１】



【図１２】



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					Ｊ
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	41/38			41/38	Ｂ
	41/40			41/40	Ｄ
Ｆ０２Ｆ	3/26		Ｆ０２Ｆ	3/26	Ａ
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